

## The last Franklin expedition: report of a postmortem examination of a crew member

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The examination of human remains from the last Franklin expedition, collected from various sites in the Canadian Arctic archipelago, has been an active research project at the University of Alberta, Edmonton, since 1981.<sup>1,2</sup> The project has included analysis of the graves and the bodies of the first three crewmen to die, who are buried in permafrost on Beechey Island, the site of the first winter camp of the expedition. The unexplained loss of the remaining 126 crew members during the final year of the expedition remains a mystery. There may have been medical factors associated with the first months of the expedition that contributed to or initiated circumstances that resulted in this extensive loss of life. The first of the graves, that of Petty Officer John Torrington, a 20-year-old leading stoker and crew member of *HMS Terror*, who died Jan. 1, 1846, was opened in August 1984. A postmortem examination was done to determine the cause of his death and discover any disease process that might be present and that might have affected the later course of the expedition.

### Materials and methods

John Torrington was buried 1.5 m below surface in a wooden coffin covered with navy blue

felt. He was clothed in shirt and trousers and was lying on a bed of wood shavings. Permafrost began 15 cm below surface. The frozen body was encased in ice.

Because of the low temperature (0°C) and high wind (15 knots), it was necessary to thaw the ice and portions of the body with warm water. Dissection was carried out beside the grave site, and, following dissection, the body was reinterred and the grave reconstructed. Preparation of the body for temporary removal took approximately 7 hours; autopsy and collection of the coffin and clothing samples took another 4 hours.

The body was opened through a Y incision; the ribs were cut in the standard autopsy fashion, the body cavities were examined, and samples of parenchymal organs, except for the pancreas and adrenal glands, which were not identified, were removed. The scalp was reflected forward, the upper skull was removed, and the brain and meninges were examined. The spinal cord was not examined. Samples of hair and fingernails were taken.

The organ samples, fixed in 10% formalin, were later blocked, prepared and stained with hematoxylin-eosin. Sections of lung, liver, heart and bowel were stained by the periodic acid-Schiff (PAS) reaction and with elastic and connective tissue stains. Specimens of heart, liver and spleen were examined ultrastructurally after conventional processing with glutaraldehyde and osmium tetroxide. Minute yellow-white nodules in the liver, 1 mm or less in diameter, were resolved with a dissecting microscope; tissue that was scraped from the nodules was placed on a copper grid, and the unstained material was analysed with radiographic

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microanalysis with an electron probe diameter of 10 to 50 nm at 75 kV. Other specimens of the scraped liver nodules were placed on a grid, stained with uranyl acetate and examined ultrastructurally without dehydration, embedding and sectioning. Similar nodules visible in paraffin-embedded sections were localized with light microscopy, the regions containing the nodules were re-embedded in Epon,<sup>3</sup> and ultrathin sections were stained with uranyl acetate and lead citrate (unpublished data: Alberta Environmental Center, Vegreville, 1985).

## Results

Torrington was 162.5 cm long, and his estimated weight was less than 40 kg. He was a small man and appeared emaciated, partly owing to postmortem dessication. He was clean-shaven and had long brown hair, which had separated from his scalp. There were no cutaneous lesions, and there was no external evidence of trauma; in particular, there were no wounds, scars, ligature marks, fractures or amputations. The face, eyes, scalp and skull were intact. Dental caries were present, and all four first molars were missing, likely from periapical abscesses. The meninges of the brain were intact and not pigmented. The brain was autolyzed, and only yellow granular fluid remained. The marked autolysis of the brain suggests that Torrington had been kept warm for a while after death, possibly while being prepared for burial while the grave was dug.

The lungs were bound to the chest wall by pleural adhesions. No masses were palpated in the apices or roots of the lungs. Sections of the lungs showed variable preservation of parenchymal architecture and good focal preservation of alveoli and of a bronchus. Anthracosis was present, sometimes associated with antemortem alveolar septal destruction; this gave an appearance of centriacinar emphysema (Fig. 1). There was a patchy, questionable increase in the amount of connective tissue, possibly an artefact of postmortem collapse. Intra-alveolar eosinophilic material, possibly an exudate, was present in one section. A fibrocalcific granuloma may have been caused by tuberculosis or a fungal disease (Fig. 2). Ziehl-Neelsen and Gomori-methenamine-silver staining showed no organisms.

The heart, after fixation, weighed 110 g and, although shrunken, was architecturally well preserved. The coronary arteries were patent, and no calcified plaques were identified. The atrioventricular, pulmonary and aortic valves were well preserved. There was no evidence of scarring, calcification or vegetations on the valve cusps. Histologic sections of myocardium showed complete loss of cellular detail.

The general outline of the intra-abdominal viscera was maintained, and there were no fibrous adhesions. The appendix was unremarkable. Mi-

croscopic examination of portions of the stomach and small and large bowel revealed no abnormalities. The layers of bowel wall were easily identified, although all nuclei and epithelial tissue had disappeared. No feces were found. The pancreas was not found, probably because of postmortem autolysis. There was no evidence of enzymatic fat necrosis. The liver was shrunken. No calculi were present in the gallbladder. Histologic preservation of the liver was poor, although the gallbladder wall was distinct. No free blood was present in the great vessels or in the abdominal cavity. The spleen was shrunken and had lost histologic detail. Bone was well preserved, but the bone marrow was almost completely autolyzed (Fig. 3). The shape of the kidneys was preserved, though histologic detail lost. The ureters were not identified, and no calculi were found in the bladder or kidneys. The external genitalia were unremarkable. Sections of pectoralis muscle were examined, and, although histologic detail was poor, no abnormality was found.

Numerous yellow-white nodules 1 mm or less in diameter were present in all organs and tissues and were composed of faintly eosinophilic, amor-

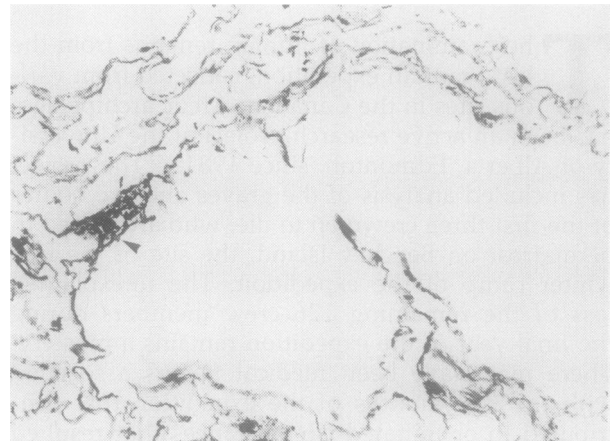


Fig. 1 — Section of right lung (Verhoeff's elastic; ×217): arrowhead shows area of anthracosis associated with alveolar septal destruction.

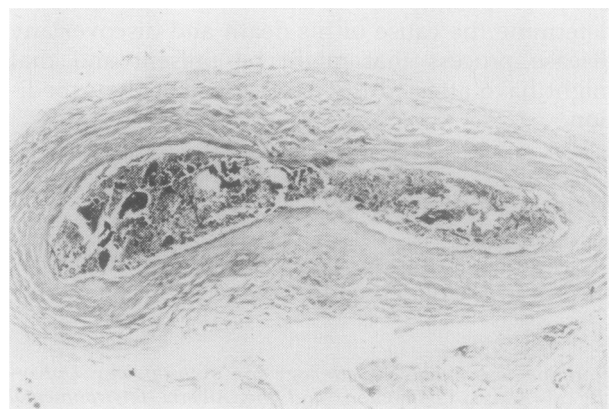
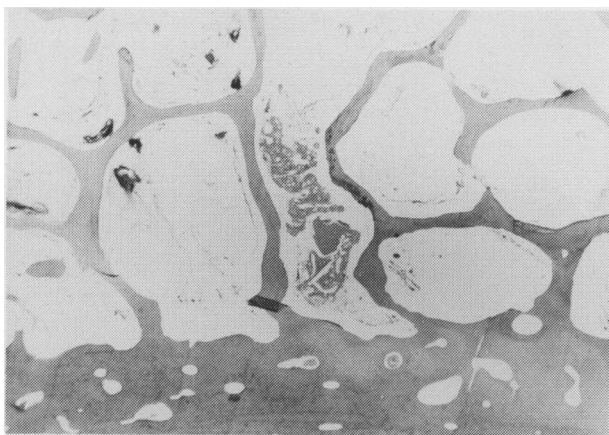


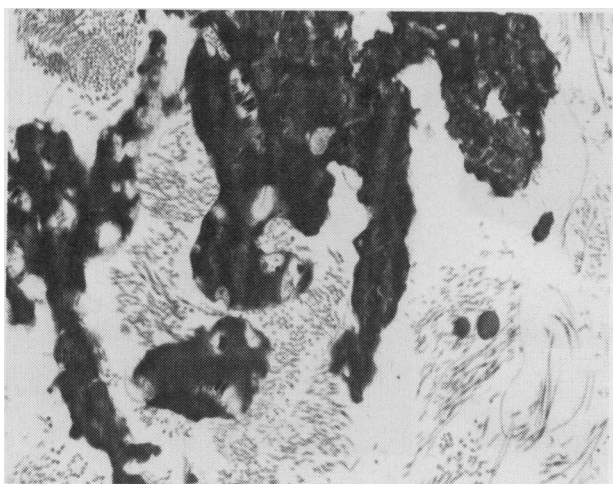
Fig. 2 — Section of left lung (Ziehl-Neelsen; ×87), containing pulmonary granuloma with thick, fibrous wall and necrotic centre.

phous and sometimes birefringent debris. The central regions of the nodules contained electron-dense, homogeneous material, cellular debris and some poorly defined structures suggestive of bacterial remains. Collagen fibres with clear 64-nm periodicity were scattered around the central region (Fig. 4). Microanalysis of the hepatic nodules with energy-dispersive radiography showed evidence of sodium, iron, magnesium/arsenic, chlorine and calcium. The magnesium/arsenic peak was due to the cacodylate buffer. Silica was not identified.

Samples of rib, clavicle and radius were analysed for lead and mercury content with an electrothermal atomic absorption method (based on dry weight).<sup>4</sup> The levels of lead varied from 110 to 151 parts per million (ppm) (normally 5 to 14 ppm<sup>5</sup>) and those of mercury from 0.03 to 1.44 ppm (normally less than 0.17 ppm<sup>5</sup>). The elevated lead level corresponds with the level of 228 ppm found in occipital bone from one of the Franklin crewmen who died on King William Island.<sup>6</sup> The significance of the elevated lead levels in determining the course of the expedition remains uncertain.



**Fig. 3 — Section of right rib (hematoxylin-eosin;  $\times 87$ ): most bone marrow has disappeared, whereas cancellous and compact bone, with exception of cellular elements, is well preserved.**



**Fig. 4 — Yellow nodule in liver ( $\times 15\,600$ ), containing collagen fibres and cellular debris.**

## Discussion

No specific cause of Torrington's death could be identified, although, because of the pleural adhesions and intra-alveolar exudate, pneumonia is likely. The possibility of a traumatic cause of death other than exposure was largely eliminated by postmortem examination. Abnormalities identified included emaciation, partially artefactual, pleural adhesions, possible centriacinar emphysema, an "old" pulmonary granuloma, possible intra-alveolar exudate, anthracosis and dental caries. The peculiar yellow-white nodules in the tissues probably represented a breakdown product of gradual autolysis. Elements commonly found in normal tissues were detected in the nodules by microanalysis with energy-dispersive radiography.

The autopsy findings do not illuminate the events that led to the loss of the remaining members of the expedition in 1847 and 1848. Current elemental analysis of hair, bone and nail samples may add information on the health and the dietary characteristics of the crew.

We thank Dr. Mudher Albassam, Alberta Environmental Center, for his advice on light microscopy, and Dr. Peter Krahn and Mr. Peter van Roosmaden, Laboratory Services Branch, Workers Health Safety and Compensation, Edmonton, for the lead and mercury analysis.

This study was supported by the Social Sciences and Humanities Research Council of Canada, the Polar Continental Shelf Project, Department of Energy, Mines and Resources, and the University of Alberta, Edmonton.

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